FORM PTO-1390
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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

DATE: December 17, 2001

EXPRESS MAIL LABEL NO.
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ATTORNEY DOCKET NO.
42637/GDL/N288

U.S. APPLICATION NO.
To be determined 10/018817

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US00/16761	**June 16, 2000**	**June 16, 1999**

TITLE OF INVENTION
METHOD APPARATUS AND ARTICLE OF MANUFACTURE FOR BRANDING A DIAMOND WITH A FOCUSED ION BEAM

APPLICANT(S) FOR DO/EO/US
Jayant Neogi

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/LUS).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.

9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). Unexecuted
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 13 to 20 below concern document(s) or other information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A FIRST preliminary amendment..
16. ☐ A SECOND or SUBSEQUENT preliminary amendment..
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ SMALL ENTITY Assertion: Applicant(s) and any other associated with it/them under 37 CFR § 1.27(a) are a small entity.
20. ☒ Certificate of Mailing by Express Mail.
21. ☒ Other items or information: Copy of Written Opinion and Response to Written Opinion. Extra set of drawings

U.S. APPLICATION NO. (If known, see 37 CFR 1.5) To be determined 10/018817	INTERNATIONAL APPLICATION NO. PCT/US00/16761	ATTORNEY DOCKET NO. 42637/GDL/N288

21. The following fees are submitted:		CALCULATIONS	PTO USE ONLY
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO:	$1,040.00		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	$890.00		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$740.00		
☒ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)	$710.00		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)	$100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 710.	
Surcharge of **$130** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	36 -20=	16	X $18	$ 288.	
Independent Claims	3 -3=	0	X $84	$	
Multiple dependent claim(s) (if applicable)			+ $280	$	
TOTAL OF ABOVE CALCULATIONS =				$ 998.	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ 499.	
SUBTOTAL =				$ 499.	
Processing fee of **$130** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 499.	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property				$	
TOTAL FEES ENCLOSED =				$ 499.	
Note (1): **The basic national fee must be paid when filing this application. The 20-month time limit (37 CFR § 1.494) and 30-month time limit (37 CFR § 1.495) are not extendable.**				Amount to be: refunded $	
				charged $	

a. ☒ A check in the amount of **$ 499.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **03-1728**. A duplicate copy of this sheet is enclosed.

NOTE (2): **Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No. EL078836312US

Applicant	:	Jayant Neogi
Application No.	:	Not yet assigned
Filed	:	December 17, 2001
Title	:	METHOD APPARATUS AND ARTICLE OF MANUFACTURE FOR BRANDING A DIAMOND WITH A FOCUSED ION BEAM
Grp./Div.	:	To be assigned
Examiner	:	To be assigned
Docket No.	:	42637/GDL/N288

PRELIMINARY AMENDMENT

Post Office Box 7068
Pasadena, CA 91109-7068
December 17, 2001

Assistant Commissioner for Patents
Washington, D.C. 20231

Commissioner:

Please amend the above-identified application as follows:

-- CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority of International application No. PCT/US0016761, which in turn claims priority to provisional Application No. 60/139,535, filed June 16, 1999, under 35 U.S.C. §119.--

Respectfully submitted,

CHRISTIE, PARKER & HALE, LLP

By _____

Gary D. Lueck
Reg. No. P-50,719
626/795-9900

GDL/gmv
GMV PAS402899.1-*-12/17/01 3:13 PM

42637PCT/RAS

METHOD APPARATUS AND ARTICLE OF MANUFACTURE FOR BRANDING A DIAMOND WITH A FOCUSED ION BEAM

BACKGROUND

I. FIELD OF THE INVENTION

The present invention relates generally to the field of the handling of precious gems and more specifically to the branding of a design onto a precious gem such as a diamond.

II RELATED ART

In the handling, marketing and sale of precious stones, such as diamonds, as well as the sale of jewelry made from these precious stones, it is common practice for jewelers and diamond merchants to grade precious stones to determine their value based on such features as cut, weight, color and the purity of the crystalline structure of the stone. These attributes contribute to much of the value of an individual stone. Conventionally, these attributes are recorded on paper or other media separate from the stone itself. These attributes and the documents which record these attributes typically become a means of both determining the value of the stone and properly identifying its owner. Thus, because this information is so important, this information must be accurately and reliably conveyed to the purchaser of the stone during a sale or other transfer of ownership.

It is equally important to the owner of a particular piece of jewelry containing precious stones to be able to accurately identify the piece of jewelry and the individual stone or stones set in that piece of jewelry. Although most luxury and consumer goods carry serial numbers or other indications of ownership, so that owners can verify their ownership of goods of similar appearances, differentiate between genuine goods and counterfeit goods at purchase,

and have an indication of ownership for insurance purposes, this is, for the most part, not the case with precious stones. Although some stones are marked with the use of lasers, the vast majority of stones on the market today are unmarked. Currently, most consumers must rely on the representations of the jeweler who sells, cleans or works on the piece of jewelry that it is in fact authentic.

In addition to and concurrent with the security reasons which would make indelibly marking stones beneficial, the ability to indelibly mark stones would also be helpful for inventory control purposes. Specifically, both wholesalers and retailers of diamonds and other precious stones have no method of placing inventory control markings, such as bar codes indelibly upon stones.

In addition to these reasons for indelibly marking stones, purchasers of stones frequently seek to personalize the stones or the jewelry in which they are set. Desired personalizations include messages, marriage certificates, and poems, as well as symbols and images.

Presently, accurate identification of precious stones for transmittal of attribute information or identification purposes is difficult because no commercially viable method for indelibly marking stones without defacing them and affecting their value is available. To preserve the value of the stone and still create an indelible marking on the stone, any marking or information placed on the stone must be extremely small, such that it is invisible to the naked eye, and preferably, to a 10X magnification power, which is the typical magnification power of a jeweler's loupe. However, it is apparent that the marking must be able to be detected in some manner for it to be of use.

Also, to ensure that markings are visible when a stone is mounted in a jewelry setting, any commercially successful marking system must be able to mark a stone on its "table," i.e.

the large exposed top surface of the gemstone, rather than on the "girdle" or edge of the stone. This is because the girdle, or sections of the girdle, are frequently obscured or placed beyond view when a stone is set in a piece of jewelry. Additionally, because the girdle of the stone is a relative exposed portion of the stone, *i.e.*, it is frequently where a stone is grasped when handled, it is very easy to scratch off or damage any markings made on the girdle of the stone. Also, an ideally cut stone has very little flat surface at the girdle, but instead has a sharp edge. If a marking is to be made on the girdle of the stone, it is sometimes necessary to cut the stone in less than an ideal cut, so that a flat surface at the girdle of the stone can be created.

Examples of prior art systems which attempted to solve the problems of indelibly marking precious stones include U.S. Patent No. 4,392,476 to Gresser, et al., which describes the use of laser energy directed at the stone to inscribe the girdle of the stone with a desired marking; U.S. Patent No. 4,467,172 to Ehrenwald et al., which describes a laser system for inscribing permanent identification markings on or below the surface of the girdle of a diamond; and U.S. Patent No. 5,149,938 to Winston, et al., which describes a method of marking a diamond on its girdle by irradiation with an argon fluorine excismer laser whose output beam is passed through a mask which defines the marking.

One feature of each of these devices is their reliance on lasers. The use of a laser to cut or mark a diamond or other precious stone results in the disadvantages of the creation of microscopic cracks in the diamond as well as a "white-frosting" effect or a “dark-regions” effect which degrade the clarity of the diamond. These effects are especially pronounced when lasers are used to mark or brand the table of a diamond, rather than the girdle of a diamond. A still further disadvantage is that the beams of most lasers are relatively wide and thus create large branding marks, i.e. large pixels as shown in Gresser, Fig. 3. This in turn limits the precision with which a marking can be made. Lasers also have limited ability to

create "grey-scale" images which depend on contrast between adjacent "pixels." It will be understood that " grey-scale" images are created by varying the depth of the brand or pit which is cut into the surface of the diamond at a given pixel. Because it is very difficult to control the depth of a cut made by a laser, accurate and reliable "grey-scale" images are difficult to produce with lasers.

Accordingly, there is a need in the art for a method of indelibly marking a diamond or precious stone without damaging the clarity of the stone. Further, there is a need for these indelible markings to be of high resolution and for an indelible marking method to be capable of producing "grey-scale" images. The present invention includes these features, as well as other features and advantages as are described below.

SUMMARY OF THE PREFERRED EMBODIMENTS

In a preferred embodiment, a diamond is branded by first securing the diamond onto a holder capable of being used in a coordinate transfer system. Next, a coordinate transfer system is used to create a set of mapping data which represents the distances between the location on the diamond which will be branded and certain set reference points on the holder. At the same time, a computer is used to convert a design to be branded on the diamond into design data capable of being processed and used by a focused ion beam machine. The mapping data is then used in conjunction with the design data to control the focused ion beam machine such that it produces a focused ion beam which impacts the diamond at a desired location for a desired length of time to brand the design onto the diamond.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 a perspective view of a diamond which has been cut and polished as a round

brilliant cut.

FIG. 2 is a magnified, planar view of the portion of FIG. 1 enclosed by Circle 2.

FIG. 3 is a flow chart illustrating the order of operation of the method of the present invention.

FIG. 4 shows a perspective view of a holder for diamonds in accordance with the present invention.

FIG. 5 illustrates an inverted, cross-sectional view of the holder of FIG. 4 along the line 5-5.

FIG. 6 schematically illustrates the positions of the diamonds and the reference points on a holder of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In a preferred embodiment of the present invention, a diamond, such as the one illustrated in FIG. 1, is indelibly marked with a design by a focused ion beam machine. It will be understood that this invention can be used for the marking of other types of precious and semi-precious stones and that although the description which follows refers, by way of example, to the marking of diamonds, this description is not to be taken as limiting. With reference to FIG.1, a diamond 100 which has been cut and polished as a round brilliant has a table 102, which is the top-most surface of a diamond when it is placed in a setting such as a ring. For the particular cut of diamond shown, the table 102 is in the shape of an octagon. The diamond is visually separated into two portions, known as the crown 104, which is the upper portion of the diamond, and the pavilion 106, which is the lower portion of the diamond. The crown and pavilion are separated by a girdle 108. The diamond also has a number of different facets 110 which serve to give the diamond its unique shape, its light

refracting properties, and which naturally define edges 112 between facets.

A portion of the table 102 encircled by Circle 2 is shown magnified in FIG. 2. With reference to FIG. 2, the edges 200 correspond to the edges 112 between the table 102 and several facets of FIG. 1. A design 202 is branded into the surface of the table 102. It will be understood by one of ordinary skill in the art that, based on the explanation below, the design could consist of images, bar codes, numbers or letters which are necessary to identify the stone, describe its attributes, mark the stone with a trademark of the manufacturer, engrave a personal inscription, mark the stone with a family crest, a copy of a photograph or whatever other marking might be desired by the user or purchaser. It is preferred that the branded design is located on the table of the diamond. This allows the brand to be observable by a microscope even when the diamond is placed in a jewelry mount or setting such as a ring. If the brand is located on the girdle or the pavilion, it can be obscured by a prong of a setting when the diamond is placed in a ring, thus frustrating the identification aspect of the present invention.

The design 202 is about two-hundred and fifty (250) micrometers wide, however the present invention is capable of producing a brand as small as seven (7) nanometers wide. At about 250 micrometers, the design is small enough that it will not be visible to the naked human eye, and will be difficult to detect with a jeweler's loupe, but will be visible with a an optical microscope with a magnification of 100X. This is the result of the shallow depth of the brand, which is preferably no more than 20-40 nm. Alternatively, it is possible to produce a brand of greater depth (such as, for example as deep as 120 nm) with the concurrent advantage of providing greater resolution for grey-scale images, however, deeper brands may be visible to a jeweler's loupe under certain circumstances.

In a preferred embodiment, the design 202 is composed of graphite bonded to the

surface of the diamond and included beneath the surface of the diamond. This embodiment allows the design to be effectively viewed by an infra-red microscope in addition to an optical microscope, because graphite is a good conductor of electricity, while diamond is not a good electrical conductor. As a result, when viewed by an infra-red microscope, design 202 will appear as a bright white image, while the surrounding diamond will be a dark grey color. Alternatively, this graphite can be removed, as described below, leaving a design in the form of a carving of varying depths in the surface of the diamond.

With reference to FIG. 3., processing begins by selecting the diamonds to be branded 300 and then cleaning them 302 before branding. It will be understood that the cleaning process can be accomplished by any acceptable process for cleaning diamonds such as immersion in an ultrasonic bath of isopropyl alcohol. Next, the diamonds must be secured to a holder which is capable of being used in a coordinate transfer system 304.

An example of one such holder 400 is shown in FIG. 4 and includes a base 402 which is composed of an electrically conductive material such as copper or aluminum. At regular intervals, holes 404 have been formed through the base 402 of the holder which generally correspond in circumference to the circumference of a cut diamond. With reference to FIG's. 4 and 5, the holder 500 has a plurality of holes 502 drilled through from the top side 504 to the bottom side 506 each hole 502 is approximately the same circumference as the circumference of a diamond to be mounted in the holder. To mount the diamonds, the holder is placed upside down, as shown in FIG. 5 so that the top side 504 is in contact with a silicon wafer 507, or some other suitable extremely level and uniform surface. One diamond 508 is inserted into each hole 502 such that its table is in contact with the silicon wafer or level surface. Once all of the diamonds to be mounted are placed in the holder, a plug 510 is inserted into the hole 502 to secure the diamond. Each plug has a small depression 512

carved in its top 514 which conforms roughly to the shape of the pavilion 516 of the diamond 508 to be mounted. Each plug is composed of a conductive material such as copper or aluminum. Each plug is secured to a diamond and the holder itself by a suitable amount of electrically conductive paste 518 or other material capable of creating a conductive bond. Preferably, the paste is composed of graphite and 2-propanol and when dry bonds the diamond to the topside of the plug 514 and also bonds the top of the plug 514 to the holder 500. Enough adhesive should be used to secure the diamond to the holder 400 so that it will not move while the holder is being handled and processed by both the coordinate transfer system and the focused ion beam machine. It will also be understood by one of ordinary skill in the art that more than one diamond can be placed in the holder at a time, and that the number of diamonds which can be processed by the coordinate transfer system at a time is limited only by the size of the holder that the particular coordinate transfer system used will accept. It will be further understood that the holes 404 can be formed to accept various cuts of diamond and precious stone and that the present invention is not limited to the round brilliant cut which is illustrated. While it is preferable that the diamond be oriented so that it can be branded on its table, the present invention is capable of modification to allow branding on any surface of a diamond. The holder 400 also includes at least three reference points 408 which are used by the coordinate transfer system.

The diamond must also be coated with a thin conductive layer 306. Preferably this layer is no more than ten (10) nanometers thick. Because the surface of a diamond builds up a positive charge, in order for a positively charged focused ion beam to effectively impact the diamond, the surface of the diamond must be charged neutral. In a preferred embodiment, the diamond is coated with a thin coating of carbon particles. This may be accomplished by a carbon-coater such as the Cressington Scientific Instruments 108 Carbon, manufactured by

Cressington Scientific Instruments. Alternatively, the conductive layer can be composed of any suitable conductive material such as, for example, gold, platinum, or chromium. In another embodiment of the invention, a charge neutralizer (also called a "flood gun") can be used to neutralize the positive charge built up on the surface of the diamond prior to and during branding with a focused ion beam. It will be understood that the order of steps 304 and 306 can be reversed, *i.e.* that the diamond may first be carbon coated and then subsequently secured to a holder.

Next, the holder is inserted by an operator into the coordinate transfer system. An example of one such coordinate transfer system is the JMAR Mirage, which is manufactured by JMAR Precision Systems, Inc. of San Diego, California. The JMAR Mirage is an extremely accurate tabletop automatic measuring system with an X-Y-Z travel of 10" x 4" x 2". The JMAR Mirage includes high powered microscope objectives and can be used with or without a laser autofocus for high speed Z-axis measurement and on-the-fly focusing of a video image of the object being measured. Optionally, the JMAR Mirage may also include microscope optics using a two-position precision automatic lens shuttle.

The JMAR Mirage then develops accurate mapping data for the diamonds in that holder, as indicated in block 308. The holder 400 shown in FIG. 4 is shown schematically in FIG. 6. The holder 600 includes holes with diamonds secured in them 602. For purposes of explanation, the table portion of each diamond 602 is shown as an octagon. The holder also includes a first reference point 604, a second reference point 606 and a third reference point 608. Preferably, each of the three reference points has a sharp distinguishable corner that can be easily identified by the video-imaging system of the JMAR Mirage. The three reference points are located at the outermost edges of the holder and are aligned with the rows of diamonds. Also preferably, the three reference points are each formed to a different

predetermined depth into the base 402 of the holder, to allow for calibration of the "Z" axis by the JMAR Mirage.

The JMAR Mirage system identifies the first reference point 604 and uses it as a base point for an X-Y coordinate system. The JMAR Mirage system accurately identifies the first reference point by using its video imaging system to locate the reference point, identify the edges of the reference point, and then fix the relative position of this reference point in its memory. This same process is then performed to locate and fix the second reference point 606, and the third reference point 608. This measuring results in the creation of an X-Y coordinate axis based on the fixed locations of the reference points. For convenience, an X-Y axis 610 is indicated in the drawing. The JMAR Mirage then proceeds to impose this coordinate system on the holder and to measure how far each diamond is from the first reference point 604 and the second reference point 606; i.e. the horizontal and vertical offsets. The JMAR Mirage further determines the exact locations of every visible surface of the diamonds secured to the holder 600. The JMAR Mirage also uses first reference point 604 and second reference point 606 to determine a reference line 612. The reference line 612 is in general alignment with the rows of diamonds in the holder 600. Each diamond 602, however, will not be perfectly aligned with the reference lines 610. Specifically, one edge 614 of the octagon shape that forms the table of the diamond is generally parallel with the reference lines 610, but at the microscopic scale, the edge 614 of the table each diamond will be rotated slighted away from being perfectly parallel. The JMAR Mirage determines the angle by which the edge 614 of each diamond is out of parallel alignment with reference lines 610. Using the JMAR Mirage Imaging system to first locate a corner on a diamond, then focus on one edge of the diamond and then trigonometrically determine both the branding point and the angle between the edge of the diamond and the reference line. This angle indicates how

far the diamond is out of alignment from the reference line and allows the JMAR Mirage to determine a rotation value. This rotational offset data will subsequently allow the focused ion beam machine to brand each diamond such that the design on each diamond is correctly positioned with reference to an edge 614 and so that design is "lined-up."

The JMAR Mirage is controlled by a computer to accomplish the functions described above. It will be understood by one of ordinary skill in the art that these functions are preferably programmed in autoTHP, but could be implemented in other programming languages. Similarly, minor modifications and variations can be made to the code without departing from the scope of the present invention.

After these functions are carried out, a set of mapping data which consists of an X-Y-Z coordinate system mapping the locations of the diamonds, as well as rotational data, has been developed. This mapping data is then transmitted to the focused ion beam machine, as shown in FIG 3, block 310.

While the diamonds are being processed as described above, the design to be branded onto them must also be processed. This begins when the operator determines the design to be applied to a diamond, or if multiple diamonds are placed in a holder, when the operator determines which design will be applied to each diamond 312. Next, the design is input into a computer by optical scanner, or electronic means such as a file transfer from a storage medium. The computer then converts the design into stream files which create a local coordinate system for the design, and then assigns X_1-Y_1-dt values to this coordinate system representing the design as shown in block 314.

After these functions are carried out, a set of design data has been developed. This design data is then transmitted to the focused ion beam machine, as shown in FIG 3, block 316.

It will be understood that the X_1 and Y_1 values will be mapped to and, when the design is branded on the diamond, these values will be integrated into the X-Y coordinate system in the mapping data. The dt data is the darkness or contrast of each individual pixel shown in the design. When the design is branded onto the diamond, the depth of the brand will be varied by varying the amount of the time in which the ion beam strikes the surface of the diamond. This in turn varies the relative darkness of that pixel of the brand.

It will be understood that this process can be done before, after, or simultaneously with the process of selecting and measuring the diamonds. However, for maximum efficiency and output from the process, it is preferred that the selection and conversion of the design be done simultaneously with the selecting and measuring of the diamonds to be branded.

Next, a computer controlling the focused ion beam machine receives both the mapping data and the design data. The focused ion beam machine itself is preferably a Gallium ion based machine. However, any liquid metal or gas based focused ion beam machine would be acceptable. An example of one such machine which is suitable for the process disclosed is the FIB 200 THP, manufactured by FEI Company of Hillsboro, Oregon. The computer maps the local coordinate system of the design to be branded, which is a part of the design data, onto the global coordinate system which is contained within the mapping data. The computer then uses this merged data to control the focused ion beam machine to accurately direct the focused ion beam so that it strikes the surface of the diamond to be branded at a particular location for a particular amount of time such that the surface particles of the diamond which are impacted by the ion beam are converted into graphite.

After these functions are carried out, the diamond or diamonds in the holder are branded and the design is formed in graphite set into the surface of the diamond.

Optionally, this graphite can be removed as shown in block 320. This can be accomplished by a number of different methods, but is preferably done by exposure to potassium nitrate (KNO_3) at 500°C for approximately forty minutes in a ceramic crucible. Alternately, the carbon can be removed by exposing the diamond to an oxygen plasma. As one of ordinary skill in the art will appreciate, the diamond to be cleaned is placed in the vacuum chamber of a plasma cleaning system, such as the Plasmod, manufactured by March Instruments of Concord, California. A gas, typically oxygen, is introduced into the chamber and electrically charged to create a reactive plasma. The plasma reacts with the graphite and removes it, while leaving the diamond untouched. The by-products of this reaction are then removed by a vacuum pump. Finally, removal of the graphite can also be accomplished by immersion in an acid bath.

CONCLUSION

The foregoing description of the preferred embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.

CLAIMS

1. A method of branding a gemstone diamond comprising:

directing a focused ion beam at the gemstone diamond to be branded and manipulating the beam such that the beam impacts the surface of the gemstone diamond at a number of specified locations for a specified amount of time at each location to graphitize a portion of the gemstone diamond in the shape of a desired design.

2. The method of claim 1 wherein the focused ion beam is manipulated by a computer.

3. The method of claim 1 wherein the design is not visible to the naked human eye.

4. The method of claim 3 wherein the design is less than 250 micrometers wide at its widest point.

5. The method of claim 3 wherein the design is between about 7 nanometers and 250 micrometers wide at its widest point.

6. The method of claim 1 wherein the focused ion beam is composed of Gallium ions.

7. The method of claim 1 further comprising removing the graphitized portions of the gemstone diamond so that the design is carved into the surface of the gemstone diamond.

8. The method of claim 1 wherein the gemstone diamond is coated with a conductive layer.

9. The method of claim 8 wherein the conductive layer is carbon.

10. The method of claim 1 wherein the gemstone diamond is exposed to a charge neutralizer.

11. A method of branding a gemstone diamond comprising the steps of:

securing the gemstone diamond onto a holder capable of being used in a coordinate transfer system;

using the coordinate transfer system to create mapping data which represents the distances between the location on the gemstone diamond which will be branded and certain set reference points on the holder;

using the mapping data to manipulate a focused ion beam machine such that it produces a focused ion beam which impacts the gemstone diamond at a desired location for a desired length of time to brand to design onto the gemstone diamond.

12. The method of claim 11 further comprising generating design data which represents the design to be branded onto the gemstone diamond; and using the design data in conjunction with the mapping data to manipulate the focused ion beam.

13. The method of claim 11 further comprising the step of coating the gemstone diamond with a layer of conductive coating.

14. The method of claim 13 wherein the charged particles are carbon.

15. The method of claim 11 wherein the holder is conductive.

16. The method of claim 15 wherein the holder is aluminum.

17. The method of claim 15 wherein the holder is copper.

18. The method of claim 11 wherein the holder is capable of holding more than one gemstone diamond at a time.

19. The method of claim 11 wherein the holder is portable.

20. The method of claim 10 wherein the holder includes at least three reference points.

21. The method of claim 11 wherein the coordinate transfer system identifies at least three reference points on the holder and determines the mapping data which comprises at least a horizontal offset, a vertical offset, and a rotational offset.

22. The method of claim 21 wherein the mapping data is determined for more than one gemstone diamond.

23. The method of claim 12 wherein the design data is converted into stream files

which comprise data representing the design in the form of pixels and offsets from a local coordinate system.

24. The method of claim 23 wherein the ion beam is manipulated to impact the gemstone diamond such that the gemstone diamond is branded wherein each impacted area corresponds to one pixel of the design.

25. The method of claim 12 further comprises the step of relating a local coordinate system associated with the design to be branded on the gemstone diamond to a global coordinate system associated with the mapping data.

26. The method of claim 11 wherein the focused ion beam brands the gemstone diamond by converting a portion of the gemstone diamond into graphite.

27. The method of 26 further comprising the step of removing the graphite.

28. The method of claim 27 wherein the graphite is removed by exposing the branded gemstone diamond to potassium nitrate.

29. The method of claim 27 wherein the graphite is removed by exposing the branded gemstone diamond to plasma.

30. The method of claim 11 wherein a voltage applied to produce the ion beam is manipulated such that the computer is able to vary how far the ion beam penetrates the surface of the gemstone diamond and how deeply the gemstone diamond is branded.

31. An apparatus for branding a gemstone diamond comprising:

a coordinate transfer system controlled by a computer;

a focused ion beam machine manipulated by the computer;

one or more computer programs, performed by the computer attached to the coordinate transfer system, for generating mapping data which represent the distances between the location on the gemstone diamond which will be branded and certain set reference points on the holder;

one or more computer programs, performed by the computer for using the mapping data to manipulate the focused ion beam machine such that it produces a focused ion beam which impacts a surface of the gemstone diamond at one or more desired locations for a predetermined length of time to brand the design onto the gemstone diamond.

32. The apparatus of claim 31 further comprising one or more computer programs, performed by the computer, for generating design data which represent the design to be branded onto the gemstone diamond and using the design data in conjunction with the mapping data to manipulate the focused ion beam machine.

33. The apparatus of claim 31 further comprising a second computer connected to the first computer wherein the first computer performs one or more computer programs for creating mapping data which represent the distances between the location on the gemstone diamond which will be branded and certain set reference points on the holder; and the second computer performs one or more computer programs for using the mapping data to manipulate the focused ion beam machine, such that it produces a focused ion beam which impacts the gemstone diamond at a desired location for a desired length of time to brand the design onto the gemstone diamond.

34. The apparatus of claim 33 further comprising a third computer connected to the first computer, wherein the third computer performs one or more computer programs for generating design data which represents the design to branded onto the gemstone diamond.

35. The apparatus of claim 34 wherein the design is converted into stream files which comprise data representing the design in the form of pixels and offsets from a local coordinate system.

36. The apparatus of claim 35 wherein the design is a bar-code.

Attorney: Gary D. Lueck
Docket No.: 42637/GDL/N288
Inventor(s): Jayant Neogi
Title: METHOD APPARATUS AND ARTICLE OF MANUFACTURE FOR BRANDING A DIAMOND WITH A FOCUSED ION BEAM

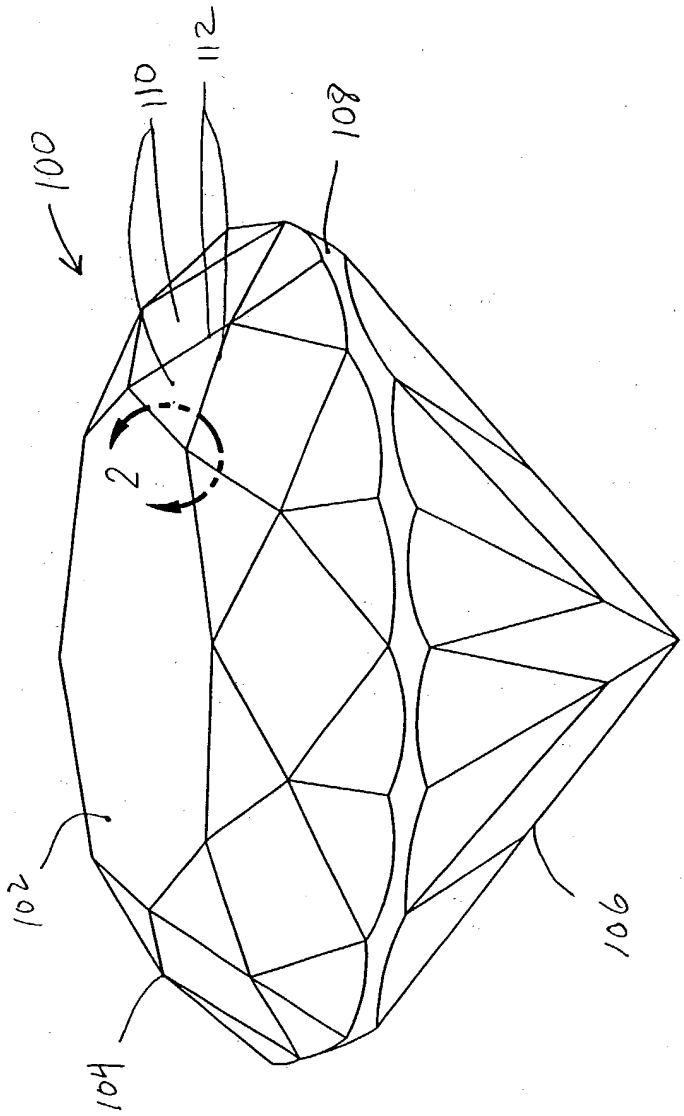
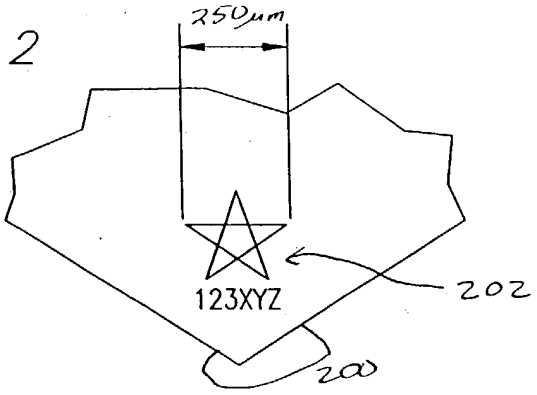


FIG. 1

FIG. 2



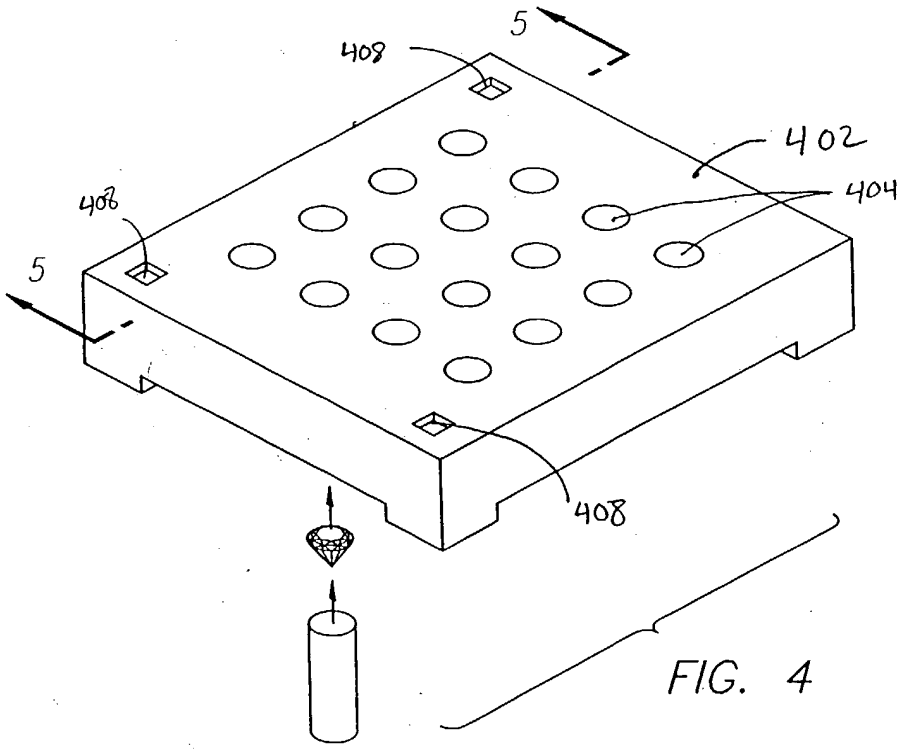
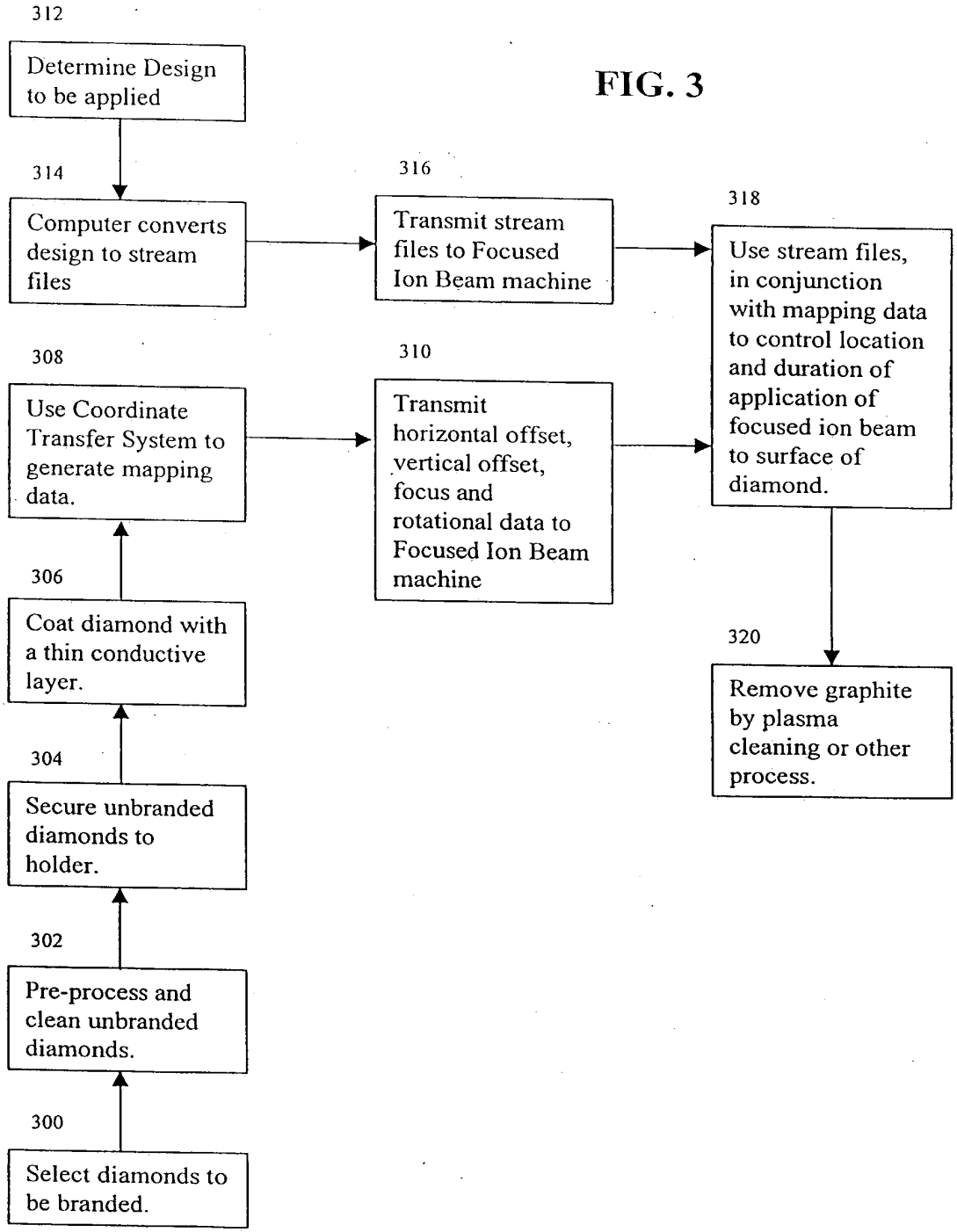


FIG. 4

FIG. 3



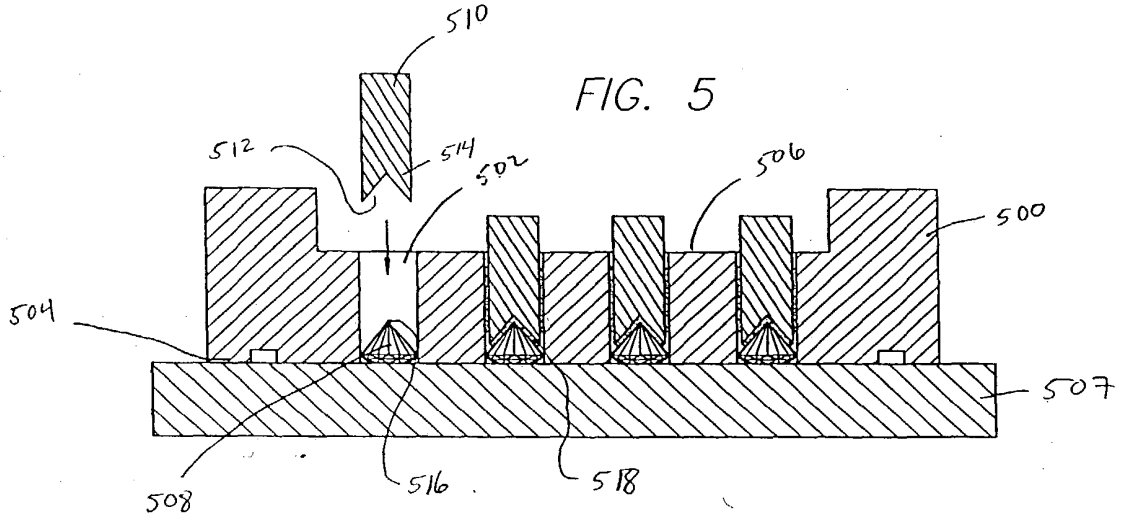

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FIG. 5

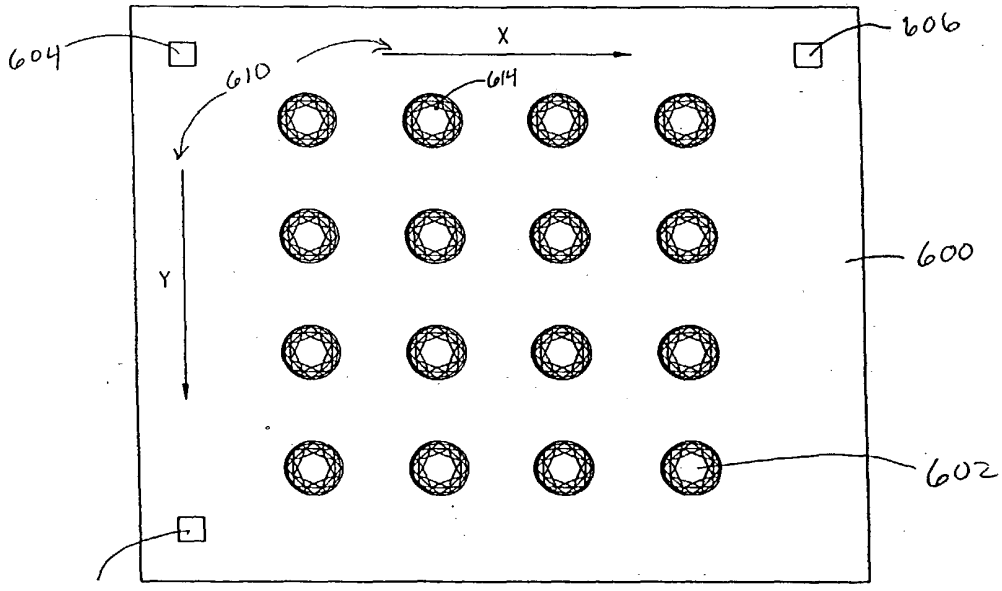
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FIG. 6

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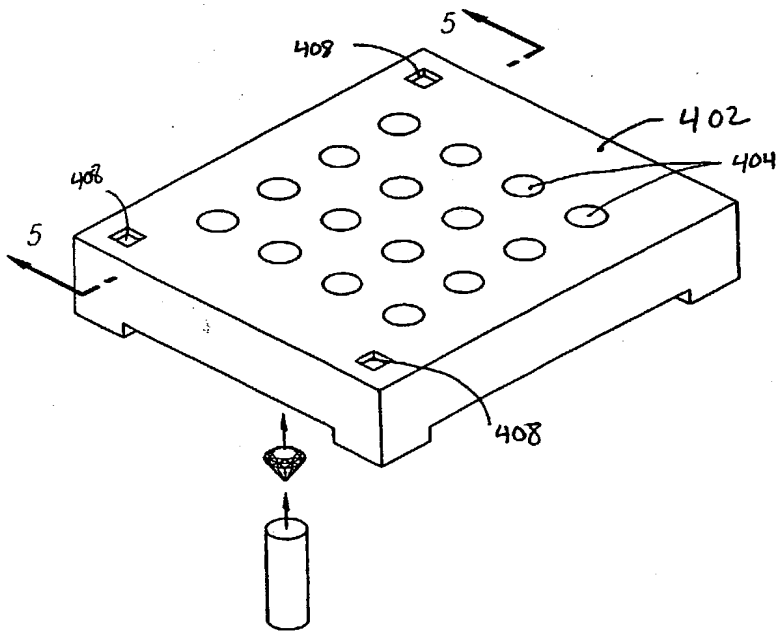
[Continued on next page]

(54) Title: METHOD APPARATUS AND ARTICLE OF MANUFACTURE FOR A BRANDING DIAMOND BRANDING WITH A FOCUSED ION BEAM



(57) Abstract: A method and apparatus for branding a diamond (100) with a focused ion beam by directing a focused ion beam at the diamond (100) to be branded (300) and controlling the beam such that the beam impacts the surface of the diamond at a number of specified locations for a specified amount of time at each location to graphitize a portion of the diamond in the shape of a desired design (202).

WO 00/76583 A1

Rev. 11/00

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

PATENT

Docket No. : 42637/GDL/N288

As President of Norsam Technologies, Inc., former employer of the sole inventor, Mr. Jayant Neogi ("Inventor"), I hereby declare that:

My residence, mailing address and citizenship are as stated below next to my name.

I believe, and based upon information and belief, the inventor is the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled METHOD APPARATUS AND ARTICLE OF MANUFACTURE FOR BRANDING A DIAMOND WITH A FOCUSED ION BEAM, the specification of which is attached hereto unless the following is checked:

x was filed on December 17, 2001 as United States Application Number or PCT International Application Number 10/018,817.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of the foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, any foreign application for patent or inventor's certificate, or any PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Application Number	Country	Filing Date (day/month/year)	Priority Claimed
PCT/US0016761	PCT	June 16, 2000	YES

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

Application Number	Filing Date
60/139,535	June 16, 1999

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112.

Application Number	Filing Date	Patented/Pending/Abandoned

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Docket No. 42637/GDL/N288

POWER OF ATTORNEY: I hereby appoint the following attorneys and agents of the law firm CHRISTIE, PARKER & HALE, LLP to prosecute this application and any international application under the Patent Cooperation Treaty based on it and to transact all business in the U.S. Patent and Trademark Office connected with either of them in accordance with instructions from the assignee of the entire interest in this application; or from the first or sole inventor named below in the event the application is not assigned; or from __ in the event the power granted herein is for an application filed on behalf of a foreign attorney or agent.

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DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Docket No. 42637/GDL/N288

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